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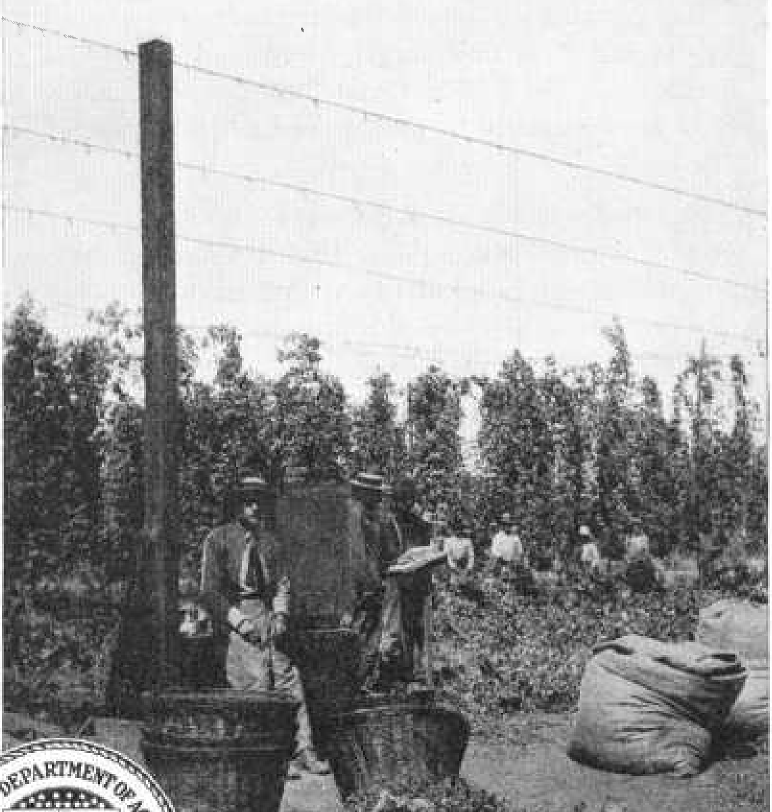
GROWING and CURING HOPS



THIS BULLETIN tells where hops are grown commercially in the United States and describes the equipment and methods used in producing the crop and preparing it for market.

Hop growing was once a thriving industry in many States, but it is now largely restricted to certain localities in the Pacific Coast States, where conditions are especially favorable for the production of this crop.

The hop acreage in the United States has been greatly reduced since 1916. High production costs and the uncertainties of the market have led many hop growers to abandon this crop in favor of others that seemed more promising.

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GROWING AND CURING HOPS.

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CONTENTS.

INTRODUCTION.

In keeping with the great progress made in agriculture within recent years the methods employed in hop production have not remained unchanged. Nevertheless certain practical principles of great importance to successful hop growing merit a much wider consideration and use than they now enjoy. These will be discussed in the following pages, in which is also presented a brief general outline of hop culture.

It is manifestly impossible to give a detailed account of methods of hop growing which would apply in all sections of the United States. The peculiar conditions of soil, climate, and location influence the prevailing methods of culture as well as the varieties grown and render it necessary for the practical grower to adopt those methods which, according to his experience, are best suited to his conditions.

CONDITIONS ESSENTIAL TO HOP GROWING.

CLIMATE.

The hop plant can be grown generally throughout the United States, but at present its large commercial production is practically restricted to areas situated in the States of Oregon, California, and Washington. Small quantities are raised in New York, Wisconsin, Idaho, Massachusetts, Pennsylvania, Michigan, Vermont, Kentucky, and Ohio. The accompanying map (fig. 1) indicates the distribution of the hop-growing regions in the United States and shows graphically how the industry has become sharply localized in districts which furnish the most favorable conditions. Long and severe winters frequently kill out many of the plants, and continued damp or foggy weather is usually followed by severe attacks of lice or mold.

While from the map it appears that hops are grown under very different climatic conditions, they are produced most successfully in the milder regions, where abundant early rainfall is followed by warm

dry weather as the crop approaches maturity. The accompanying chart (fig. 2) shows the average monthly rainfall in the chief hop-raising sections of the United States. In the Yakima Valley, Washington, where the rainfall is very scanty, irrigation is necessary. The hop plant readily adapts itself to very different conditions of rainfall, but when the harvest months—August and September—are accompanied by much rainfall the crop frequently suffers heavy damage from lice and mold.

SOIL.

The selection of the best soil on which to grow the hop plant involves the consideration of several factors, depending on the peculiarities of the plant itself and the physical conditions of the region in which the land lies.

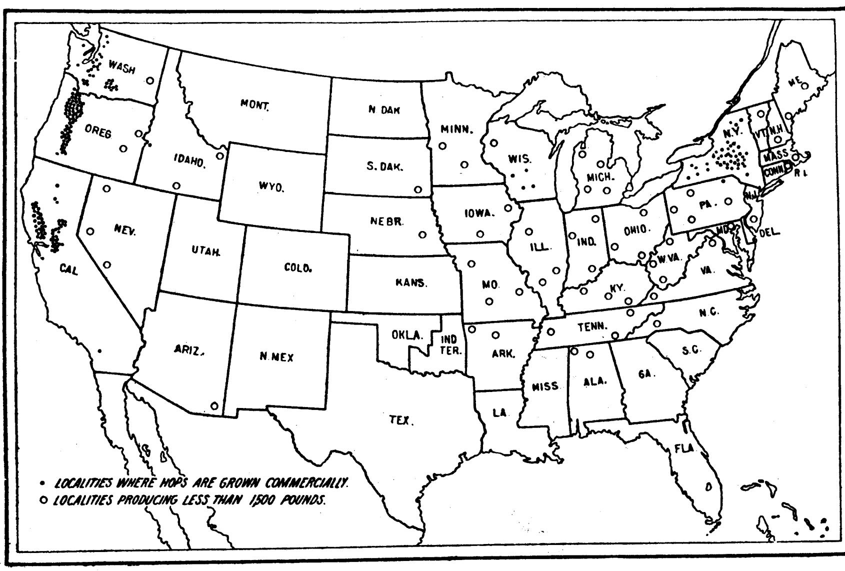

FIG. 1.—Map showing the hop-producing areas of the United States.

In general, rich alluvial lands or deep sandy or gravelly loams are preferred for hop raising. The soil with a high percentage of sand is readily tillable, while the cultivation of a stiff soil is difficult and expensive. Owing to variations in the rainfall, amount of sunshine, and force of the prevailing winds, land suitable for hop culture in one region would be entirely unsuitable if located in another. Since the roots of the hop plant penetrate the earth for a distance of many feet, a well-drained subsoil is essential. Especial attention must be given to the depth, fertility, drainage, and fineness of the soil. Heavy wet soils are avoided and stiff clayey soils are in general disfavor.

PROPAGATION.

PROPAGATION FROM SEED.

Hop plants may be raised from the seeds, but this method is seldom employed, since by using cuttings strong plants are more easily and quickly secured. Moreover, seedlings have a tendency to vary greatly, both as to the time of maturing the hops and the quality of the product. Yards planted with seedlings usually show little uniformity in the variety of hops produced and in the time of ripening. Except in certain localities, seedlings will not produce hops the first year, and even in the second year only a small yield may be expected.

USE OF CUTTINGS.

The simplest method of growing hop vines is from root cuttings, also called "roots" or "sets." In some localities roots that have

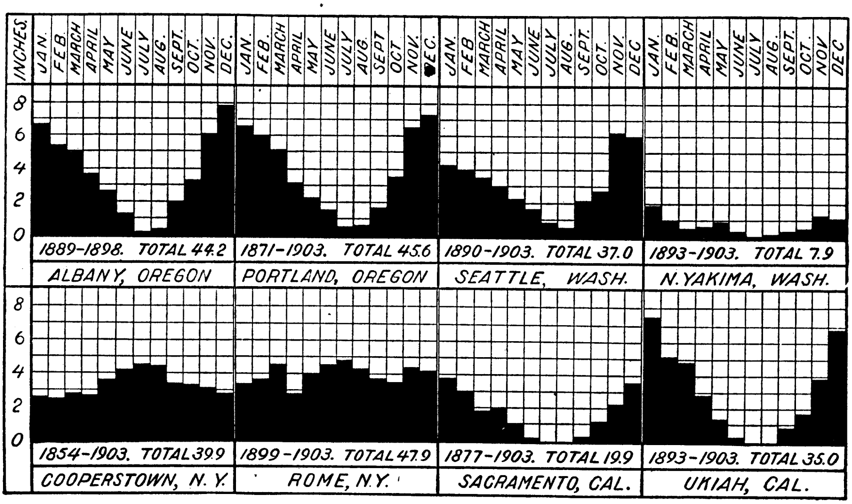

FIG. 2.—Chart showing rainfall in the principal hop-growing regions of the United States. The average rainfall at the places named during each month in the year for the period of years indicated is shown, together with average totals for the same years.

been in the nursery for one year are called "sets." The numerous runners sent out by the hop plant just below the surface of the ground are removed when the plants are pruned in the spring, and these, cut into pieces each bearing at least two sets of "eyes" or buds, are used to produce new plants.

In some sections of the Pacific coast a crop may be obtained from cuttings planted in the spring, but in general a full crop is not harvested until the second year.

The best cuttings are those taken from young plants, as they are more resistant to disease and should be more productive than those from old plants. All cuttings should be carefully inspected before planting and the diseased or damaged ones rejected.

ORIGINATING NEW VARIETIES.

The important subject of originating new varieties, as well as the no less promising one of improving existing varieties, merits the attention of every hop grower. The plants of every field are more or less variable. Some bear more heavily than others, some are richer in the desirable resins, and some will show other high-grade qualities. New varieties may be sought for among the plants in the nursery when these are grown from seed. After the seedlings have been transplanted to the yards and have matured a crop a careful examination at picking time may show that some have superior qualities. These should be suitably marked and cuttings made therefrom the next season for further selection. There is no good reason why this method if persisted in should not produce valuable new varieties. The favorable results obtained with new and improved varieties of corn, wheat, grapes, and other crops may be duplicated in hop culture and suggest lines along which improvement may be made, particularly in regard to bettering the quality of the product.

SELECTION.

The opportunity for producing improved sorts by selection of the stocks from which cuttings are taken offers a promising field for the progressive hop grower. Many growers who give much attention to improving the fertility of their fields and their methods of cultivation take their cuttings for planting from the nearest available supply without any consideration of the productiveness and other qualities of the plants from which the cuttings are taken. This has resulted in many yards in the loss of certain distinct varietal characteristics, and in almost every field mixed varieties and light and heavy producers occur indiscriminately.

A careful study of the productiveness of an acre of hops in California has shown that the yield of individual hills varied from a few ounces to 18 pounds of green hops. When the number of these low-yielding hills is large the total yield will be correspondingly reduced. Such hills should be removed and replaced by roots taken from plants giving high yields.

In certain sections the hop plant is affected by a crown gall which is known locally as "root-knot" or "warts." A rigorous selection of new roots used is necessary not only to avoid setting out roots already diseased, but that roots may be obtained, if possible, which will be resistant to the attacks of the disease itself.

A decided improvement in quality should follow the careful selection of cuttings with reference to productiveness, uniformity, disease resistance, and general adaptability to the cultural conditions in the region where they are to be grown. The selection should be made at picking time, when the hills containing plants of superior quality and productiveness can be staked, so that cuttings may be taken therefrom the next season.

PLANTING AND CULTIVATING.

TIME TO PLANT.

The time at which planting is done depends very largely on the local conditions existing where the crop is grown, but in general the best results are obtained by planting as soon as the soil can be worked into a fine mellow condition. In California planting should be done in January or February, although in some seasons planting as late as May 1 has yielded good results. In Oregon and Washington hops are planted in March or April, and in New York successful plantings have been made in April in favorable seasons.

SETTING THE ROOTS.

In California practically all new hops are now set out in rows at a distance of $6\frac{1}{2}$ to 7 feet apart each way. When set $6\frac{1}{2}$ feet apart, there will be 1,031 hills to the acre and $42\frac{1}{4}$ square feet of soil to the plants of each hill; when set 7 feet apart, there will be 889 hills per acre and 49 square feet of soil to the plants of each hill. In Oregon and Washington, where two horses are used in cultivating, the distance between rows is usually 8 feet, requiring but 680 plants per acre.

The methods of cultivating the hop yards necessitate straight rows. Three and often four cuttings are set in each hill. Differences of opinion and practice exist, and the number which it is advisable to set is in a measure dependent on the system of training employed and the cost of roots. The setting of a fourth root is a measure of precaution against the possibility of loss by rotting or injury of one or more of the cuttings after they are set out.

A good method of setting the roots is first to mark the center of each hill by a small stake, to which are to be attached the strings on which the vines are to run; then, about this stake to make three holes forming roughly the apexes of an equilateral triangle with a side measuring about 6 inches. These holes are usually made with a dibble, but in very compact soils an iron crowbar is frequently used. The roots are then placed singly in these holes in an upright position, with the buds pointing upward, at such a depth that they will be from 1 inch (in Oregon) to 3 inches (in California) below the surface of the soil, which is then slightly tamped about them. Another

method is to make a hole with a spade at the location of the hill and to plant therein from one to four roots, according to their strength. This is the more rapid method but is less desirable, since the roots are crowded together and are more subject to decay.

The price of roots is quite variable, ranging from $1 per 1,000 when they are plentiful to from $8 to $10 per 1,000 in years when they are scarce.

CULTIVATING.

Thorough cultivation is important and should begin early and continue until the plants are well armed out. This is necessary not only to keep down the weeds, but also to prevent the topsoil from forming a crust and becoming hard, for when it is in this state the moisture of the undersoil rises to the surface and evaporates quickly. The frequent stirring of the topsoil to a depth of 2 or 3 inches will produce a layer of finely divided soil which conserves the moisture near the surface, where it is more readily reached by the young feeding roots which develop at about the time the hops go into the burr. If these small feeding roots are destroyed or seriously injured by late cultivation, growth will be checked and early ripening favored. Careful growers agree that the young buds do not set so well if the feeding roots are seriously disturbed, and that the crop is shorter in consequence. Nevertheless, if the soil is becoming hard and the moisture is readily evaporating, it may be best, at least in dry sections, to cultivate and depend upon a second growth of the feeding roots for the proper maturing of the crop. The existing soil conditions must determine the advisability of cultivating after the appearance of the feeding roots.

PRUNING.

By the process of pruning, the excess shoots from the rootstock are removed and the formation of fewer but at the same time stronger vines is favored. The rootstock itself also is reduced to an acceptable form and suitable depth below the surface of the soil, and the formation of undesirable runners is retarded or suppressed. The working over of the ground incident to pruning also is an important part of cultivation.

Within certain limits determined by local conditions, the length of the growing period and the time of ripening may be influenced by the earliness or lateness of pruning. The general practice is to prune early in the spring, the exact time being determined by the season and the locality.

A common practice is to draw four or five furrows with a small plow on each side of the row, turning the earth away from the hills. The yard is then cross-plowed in a similar manner, leaving each hill

a small undisturbed square. The earth is then hoed and grubbed away from the roots, and the superfluous roots and runners, together with an inch or two at the top of the root crown, are cut off with a sharp knife. After pruning, the hoe is used to pull the soil back upon the hill, covering the rootstock to a depth of 2 or 3 inches. Too much pruning by this method causes disease, and frequently uneven pruning causes the late coming out of the overpruned vines.

Another method which offers several advantages over the former is to prepare the ground by plowing as before, using a coulter on the plow in drawing the last two furrows. The hill is not dug into, but instead a sharp spade is used, with which each side of the hill is cut down on a slant from top to bottom, leaving the hill about 4 inches square at the top and 12 to 14 inches square at the bottom. With this method baking of the soil over the hill is avoided and the new shoots come through much more easily. The pruning is more even and the rootstock suffers less from wounds and bruises than by the former method.

The eyes or buds on the upper part of the rootstock begin to grow earlier in the spring than those on the lower portion. But the shoots from the lower eyes make a much more rapid growth; hence, it is desirable to remove the upper eyes in pruning. This fact is of special importance in regions subject to late frosts in spring. Care should be taken in pruning the root crown not to remove all of the new wood formed in the preceding summer, since the eyes on the old rootstock produce weaker shoots than those on the new wood. In pruning, each plant must receive individual treatment according to its condition and state of development. The number and strength of the vines produced after pruning afford the best means of judging the correctness of the pruning as well as the soundness and vigor of the rootstock.

The later development of the plant is much modified by pruning. Longer, stouter, and better developed vines, longer arms, and more abundant strobiles or cones result when the pruning has been properly done. In wild hops which have been pruned for several years it has been found that the form of the cones has been modified and the lupulin content increased. There is good reason to believe that if more attention was paid to the important process of pruning a substantial increase both in the yield and quality of the hops produced would result.

TRELLISES.

The use of hop poles (fig. 3) has been largely discontinued in those regions where there is a scarcity of available timber, and even in heavily wooded sections many growers have dispensed with them.

This is not due to the labor and expense of handling alone, but experience has proved that the advantages of growing hops on strings so far surpass the growth on poles that it is only a question of time when poles will be almost entirely abandoned. The hops are healthier on strings, more successfully sprayed, mature earlier, are usually richer and brighter, arm out lower, and are not so leafy; they do not windwhip so readily, can be picked cleaner, and are much more easily torn down for picking. Also the hops can be picked without cutting the vine, a practice which is harmful, since it prevents the return of

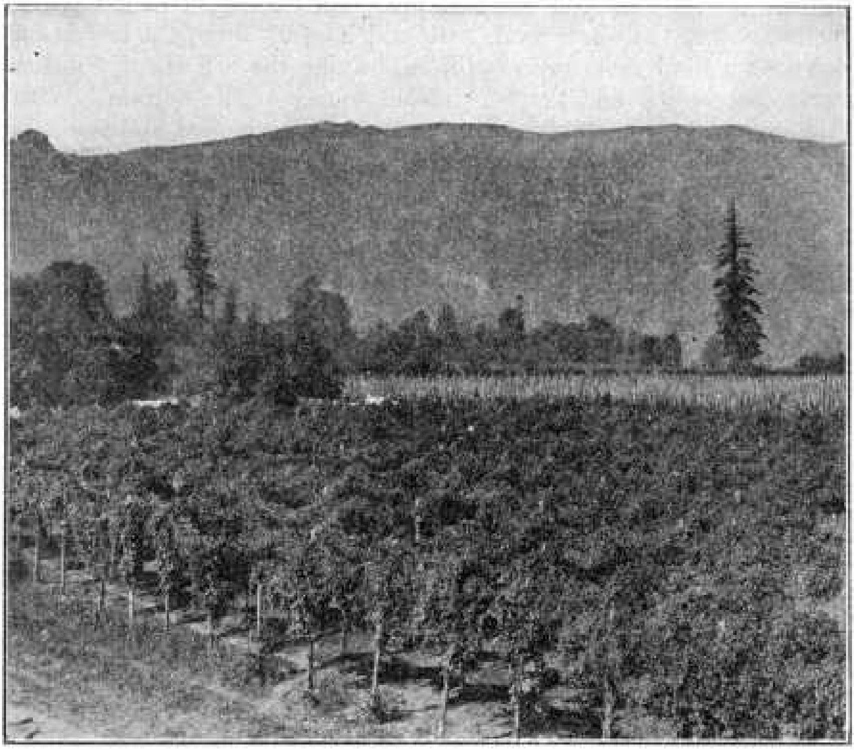

FIG. 3.—A field of hops growing on poles.

materials from the vine to the root of the hop, and, by causing a loss of food reserves to the stock, produces a weakening effect on the succeeding crop.

For a permanent yard some form of the wire trellis shown in figure 4 will doubtless give the best satisfaction in most sections. In sections where timber is plentiful the first cost somewhat exceeds that of the pole system, but the saving in labor, the advantages afforded in spraying, and the heavier crop obtained by this method have uniformly reduced the cost of hop production where poles have been replaced by wire trellises.

The wire trellis is constructed in almost numberless ways, but these may all be included in two general classes or types—the high and the low trellis. The high trellis is most widely used, and upon it the greatest improvements have been made.

THE HIGH TRELLIS.

The high-wire system consists essentially in setting posts at every sixth or seventh hill throughout the yard. Over the tops of these posts wires are stretched across the yard each way at right angles (fig. 5). Posts are also set at the ends of the intervening rows, between which wires are stretched over the rows. These wires are

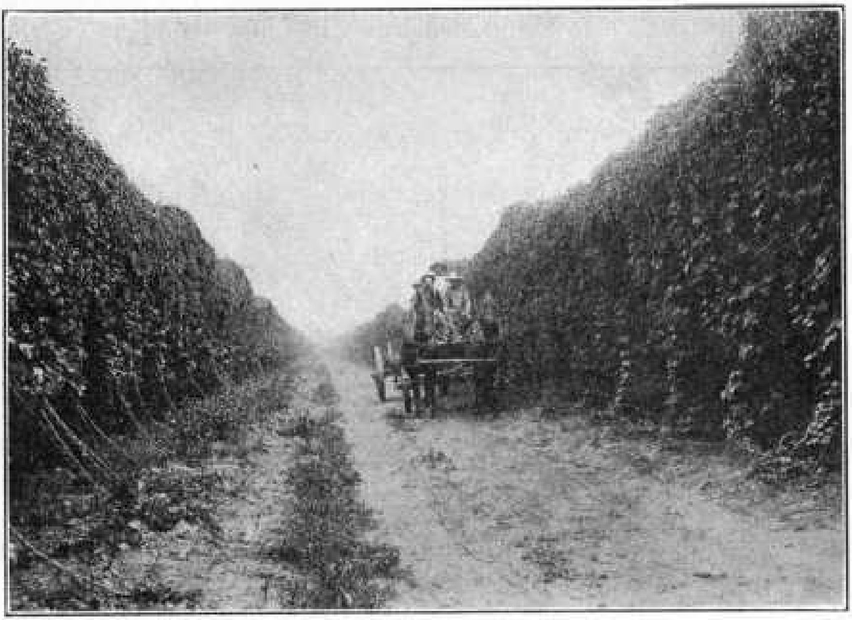

FIG. 4.—Roadway between fields of hops, showing a fine growth of vines on high-wire trellises.

fastened to the cross wires, and strings led up to them from the hills support the vines.

For posts, which may be either split or sawed timber, suitable hard wood or creosoted pine is used. These posts are usually from 4 to 6 inches in diameter and 20 feet long. The end posts should not be less than 6 by 6 inches, but somewhat lighter timbers may be used for interior supports. The posts are set from $1\frac{1}{2}$ to 2 feet in the ground, the interior ones upright, those in the outside rows inclining somewhat outward. At a distance of about 14 feet outward from the foot of each end post an anchor, made of a piece of timber 6 by 6 inches and 4 feet long, is buried at a depth of 4 to 6 feet, according to the tenacity of the soil. Anchors made from locust are preferred,

because of the lasting quality of the wood. A strong guy wire is run from the top of the post and fastened securely to the anchor; or the string wire may be run over the top of the end post and down to the anchor.

To permit easier access to the field, posts are frequently placed at the ends of alternate rows only. The string wires of the rows without end posts are then either run over the end cross wire to the ground and anchored or they are forked and fastened to the end posts on each side. For the principal or cross wires running across the field the shortest way and fastened on the top of each post with heavy staples No. 0 annealed iron wire is used. These wires are keyed up taut and fastened securely to anchors at each end. For the other or string wires Nos. 6 to 8 annealed iron wires may be used. On the

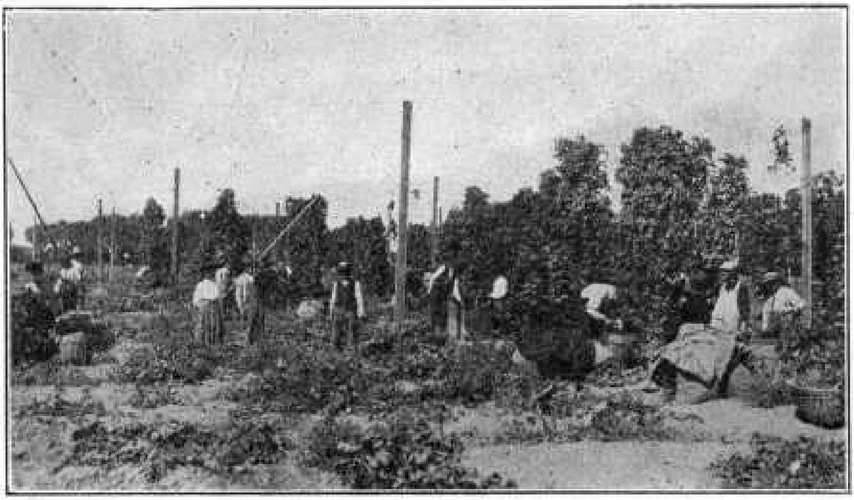

Fig. 5.—Field of hops, showing details of the drop-wire trellis and method of picking.

latest improved or drop-wire trellis shown in figure 5 the string wires are held in place underneath the cross wire by short S-hooks made of No. 2 wire. At picking time the string wires may be unhooked and let down, thus bringing the hops within easy reach of the pickers. This trellis can usually be erected at a cost of \$80 to \$90 an acre, and twine for supporting the vines necessitates an annual expenditure of about \$5 an acre.

In another successful form of this system an additional wire, known as the "breast wire," runs over each row below and parallel to the string wire at a height of about 6 feet from the ground. The strings rise vertically to the breast wire; then they are taken on the slope to the top or string wire, which is above the next row of hills. The angle of the sloping string is affected by the distance between the rows as well as by the height of the breast wire. The steeper the

slope the better the growth of the vine. At half slope hand training will be necessary, but a flat slope gives better exposure to the sun and increases productiveness.

THE LOW TRELLIS.

The low form of trellis appears in several modifications. In one form poles about 8 feet long are set at each hill. Over the tops of the poles wires are run the full length of the yard each way, crossing at right angles. The vines are led up the poles or stakes and then find support on the wires. In many cases stout twine is used instead of wire, and in some instances the poles are set at every third hill.

Except in situations swept by strong winds, the high trellis is much more satisfactory. It is a permanent structure which gives easy access for teams to every part of the yard. The hops receive more uniform exposure to light and air and are in consequence better developed. Cultivation is not interfered with by drooping arms so much as in the low-trellis system. The hops can be readily sprayed even at picking time, when the worst attacks of lice are likely to occur. Since a hop vine will not follow a horizontal support, when it reaches the wire or string of the low trellis it must be trained by hand, thus materially increasing the cost of cultivation.

SYSTEMS OF TRAINING.

STRINGING.

Where the high-wire trellis is employed, cotton cord is used to form supports for the vines until they reach the wires. The string consists of two portions knotted together; one, a cord 4 feet long having a breaking strain of 80 pounds, is attached to the wire, and the other, a cord 15 feet long having a breaking strain of 20 pounds, is tied to a small stake set in the hill. The smaller cord is strong enough to support the vine until it reaches the heavier cord at the top. Good hemp is often used for the top string instead of cotton cord. The string may be fastened to the wires by means of a special knot-tying device attached to the end of a long pole, but the plan pursued in the trellis fields where the drop-wire system is used is simply to unhook and lower the string wire (fig. 5), to which the strings may then be attached by the workmen while standing on the ground. The strings, which are cut to the desired lengths and knotted in advance, are fastened to the wires about 20 inches from a point on the wire directly over the center of each hill. Usually but two strings are used for each hill, and when all have been fastened to the wire it is again hooked up in place on the cross wires.

Another plan is to use a " trellis wagon," on which is a platform of such elevation that the workmen thereon may move about freely

beneath the wires while attaching the strings. The wagon follows the string wire across the field. Two or three men on the wagon will put the strings on two wires as fast as the team can walk. Four men following the wagon can fasten the ends of the strings to small stakes set in the ground at each hill.

In some pole yards a loop in one end of the string is passed over the top of the pole by means of a forked stick, and then drawn taut. The remaining end is then fastened to the adjacent pole in the next row about 5 feet from the ground. Frequently another string is fastened from pole to pole at the same distance above ground.

TRAINING.

When the young vines are about 2 feet long training is begun. Usually the four runners most closely approaching in length the average of the field are selected from each hill and the remainder are cut off. In case of an uneven stand it may be well to cut off the whole field and wait for the second set of runners. However, vines which may be inferior at first sometimes develop a vigorous growth after they have reached a length of 4 or 5 feet. As a general rule, in all light producing sections it is advisable to train the first runners; in heavy producing sections the second runners should be chosen. Two runners are usually trained to each string, care being taken to twine them from left to right about the string.

It has been shown that under certain conditions the yield per hill is directly proportional to the number of vines trained. Except on very heavy cropping land better results should follow when six vines to each hill are trained than with a smaller number.

In pole yards some farmers train seven vines up each pole, three for the long string and two each for the other string and the pole.

PICKING.

TIME TO PICK.

The time when hops should be picked varies with the locality, the season, and the variety cultivated. When the acreage is large there is a tendency to start picking before the crop is fully mature, as otherwise a portion may be lost through becoming overripe. Also a great consideration with many growers is the early engagement of pickers. To this end it is customary in some sections to plant an early-bearing variety, e. g., Fuggles, which ripens from a week to ten days earlier than the other standard varieties and enables the grower to begin picking so much earlier.

A second consideration is the capacity of the drying plant to handle the crop as fast as harvested. If the acreage is large and the crop heavy, the facilities for handling and drying the hops will be taxed to their utmost, and if more hops are picked than can be put upon the kilns and dried without delay, they undergo heating, and are thereby seriously damaged in quality or lost entirely. Because of inadequate facilities, therefore, growers frequently begin picking before the hops are ripe and continue picking after they have passed what is recognized as the most suitable stage for harvesting.

A third consideration, which is recognized by all progressive growers, is the effect of the picking time upon the quality of the product. The development of the essential oil, the desirable soft resins, and other valuable constituents reaches its height about the time the hops become fully ripe, in which condition they are generally regarded as possessing the finest flavor.

From the standpoint of the consumer the time of picking is a matter of great interest, and it should be also to every grower, as a much higher quality of hops would result from picking at the proper time. However, for reasons previously mentioned it is often very difficult to secure pickers when the crop is just ripe. In addition to the difficulties just mentioned, the several parts of the field rarely ripen exactly together; often when a field is practically level slight variations in quality of soil or moisture content will result in unevenness in ripening, and while it is customary in picking to work around and through the field, choosing first the ripe portions, it is rarely possible to pick all of the crop at the most desirable degree of ripeness.

While growers recognize in a general way the importance of a proper picking time, the disadvantages arising from a disregard of this time are not appreciated by all. There are several important objections to improperly picked hops which reduce their market value.

NECESSITY FOR CLEAN PICKING.

In picking every effort should be made to reduce to a minimum the quantity of leaves, stems, and other foreign material. The presence of leaves in cured hops renders them unsightly and materially reduces their market value. The opinion is frequently expressed by the more important hop dealers that one of the principal points for raising the quality of the American hop is clean picking.

DISADVANTAGES OF UNRIPE HOPS.

Unripe hops contain more water in proportion to their weight of dry substance than those which are ripe; consequently in drying the "conversion" is not so high; that is, the ratio of the dry hops to the weight of green hops put upon the kiln is smaller when the hops are

unripe. Unripe hops are also more difficult to dry on the kiln, probably because of their higher water content and tendency to pack together as soon as wilted, and they do not keep so well when stored. Since the lupulin in unripe hops has not reached its full development, there is an absolute loss of weight by picking in this condition. The aroma is not so well developed and the amount of resins is smaller in the unripe hop. Not only is there a loss of weight due to too early picking, but practically all of the desirable qualities upon which the value of the hop depends are also in large measure diminished.

TESTS FOR RIPE HOPS.

By means of certain practical tests the degrees of ripeness and suitability for picking of the hop may be readily determined. (1) The strobiles or cones, which are bright green in color in the vegetative state, change gradually to a bright yellowish green as they approach ripeness. This is not always an exact test, as the color is somewhat dependent upon the soil and some other factors. Some hops have a greenish color when they are ripe. Sometimes in fields infested by the wild morning-glory a yellowing of the cones may occur, which is not due to ripening, but rather indicates an unhealthy condition in the plants themselves. (2) Immature hops are soft and pliable and have no resiliency or elasticity. As they ripen, however, they become more and more elastic, and if slightly compressed between the fingers will, on being released, assume at once their original condition. (3) When hops have a crisp feeling and give forth a rustling sound when crushed in the hand they are regarded as ripe. (4) The so-called seeds of the hop are in reality fruits, the seed being covered by a closely adhering pericarp, which, when the hop is ripe, takes on a dark purple color. At this time also the seeds fill out and become hard. (5) The bracts at the point of the cone close as ripening progresses, and the cones themselves feel sticky or greasy. (6) Immature hops have little odor aside from the natural green or plant odor until they are near ripeness, when the characteristic lupulin odor becomes very marked. (7) As the hops approach maturity the upper foliage leaves change from light green to dark green, while those on the lower part of the plant turn yellowish and drop off.

CURING.

THE OBJECT OF CURING.

The primary object of curing hops is to reduce rapidly their moisture content to such a degree that they may be safely stored and their properties preserved. Hops must be dried soon after their removal from the vines, as otherwise they undergo a process of oxidation or heating which seriously injures their appearance as well as their

aroma and other valuable qualities. According to the variety and the degree of ripeness when gathered, freshly picked hops contain 65 to 75 per cent of moisture, but when in a dry state fit for storage or marketing they should contain only from 10 to 14 per cent of moisture. Increased knowledge of the constituents and properties of hops has extended the idea of curing to include the production of a hop which not only has a fine physical appearance, but which also contains the maximum amount of the desirable principles upon which its intrinsic value is based. The most important of these principles are the tannin, found mostly in the bracts of the cone, the soft resins, the volatile oil, and the bitter principles which occur chiefly in the lupulin. Curing is all too frequently conducted with regard to the physical appearance alone, and the methods employed often injure the quality of the hop through their harmful effects on the oil, lupulin, etc.

THE THEORY OF DRYING.

The removal of moisture from hops constitutes drying. In the atmosphere this is ordinarily accomplished by evaporation, a process which is dependent upon the ability of the air surrounding the drying hops to carry off the surface moisture in a vaporized state. The amount of moisture in the form of vapor which the air can take up depends upon its dryness, since there is a maximum amount of vapor which the air can contain. When this maximum is reached the air is saturated or at the dew point and will take up no more moisture. In order that drying may proceed the saturated air must be constantly replaced by drier air, and a brisk artificial circulation therefore hastens the process.

The ability of the air to take up moisture varies with its temperature, and an immediate effect of heat on the atmosphere is to increase its capacity to absorb aqueous vapor; for example, it has been determined that the moisture in 10,000 cubic feet of air saturated with aqueous vapor at 62° F. weighs 8.77 pounds. On raising the temperature of the air to 82° F. the 10,000 cubic feet of air can take up 7.83 pounds additional moisture; and by increasing the temperature to 122° F. 42.53 pounds additional can be carried. If, however, the air at 62° F. is only half saturated, 10,000 cubic feet will contain but 4.38 pounds of moisture; then raising the temperature to 82° F. will enable the 10,000 cubic feet to take up 12.22 pounds additional, and increasing the temperature to 122° F. admits of 46.92 pounds additional being carried.

The volume of air necessary to effect drying within a given time is dependent upon its temperature. Because of its greater moisture-carrying power a small volume of air at a high temperature will absorb and carry away an amount of vapor the removal of which

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would require a relatively large volume of air at a low temperature. If half-saturated air heated to 162° F. in passing over a moist surface at the rate of 10,000 cubic feet per minute removed therefrom in that time 130 pounds of moisture, it would require about twenty-three minutes to carry away 3,000 pounds of moisture. If, now, the same air were cooled to 82° F., 10,000 cubic feet per minute could remove about 12 pounds, and nearly four and one-half hours would be required to remove 3,000 pounds of moisture. To carry away the moisture in the same time as the air at 162° F. a volume of about 108,000 cubic feet per minute would be required.

In practice it has been found that the air driven through a mass of hops does not become fully saturated with moisture, and only during the early stages of drying does the amount of moisture actually removed approach the quantity which would be removed if the air carried its full capacity. At the temperature commonly used in drying, therefore, a much larger volume of air must be provided to remove a given amount of moisture than apparently would be required from a consideration of the figures given.

A certain degree of heat is always advantageous in drying hops because of the conditions under which the moisture in them occurs. A part of this moisture is free water and is the first to be exhausted in drying. The rest forms a part of the sap and tissues, and its removal affects the physical condition of the drying hops. Heat, by raising the temperature of the tissues and cell sap, promotes the passage of water to the surface, where it may be removed by vaporization. An artificial supply of heat is also necessary to replace that lost from the hops by the process of vaporization; otherwise the temperature of the moisture held in the cells will remain so low that it will not move readily to the surface and drying will be retarded.

In drying hops good results, however, are not obtained merely by supplying a high degree of heat below the floor of the kiln. When hops are piled on the floor at a depth of from 14 to 30 inches, they form an extremely poor conductor of heat. Not only are the hops themselves a poor conductor, but the air heavy with aqueous vapor filling the spaces between the hops offers much resistance to the transfer of heat. It thus happens that when heat is applied to the floor of hops the moisture of the lower layers is driven off, the air in contact with them becomes saturated, and, rising quickly, comes into contact with cooler layers. Here the saturated air is cooled, with the result that its moisture is condensed and deposited on the upper layers of hops until they become wet and soaked. The continuous application of heat thus results in the lower layers becoming dried out and overheated, while the heat gradually working upward through the wet layers of hops subjects them to a harmful steaming process. The difficulty is frequently increased by the practice of

turning the hops, as in this way the overdried layers from the bottom are brought to the surface and again steamed and dried.

It is evident that a rapid and continuous removal of moisture is desirable, and to accomplish this draft and ventilation are necessary. A strong draft is necessary to insure a rapid movement of the heated air through the layers of hops, since by rapid replacement of the air in contact with the moist hops time is not afforded to approximate the point of saturation; hence, the air can undergo a considerable degree of cooling in the upper layers without reaching the dew point and depositing its moisture. Top ventilation is necessary to remove the vapor-laden atmosphere from above the hops; otherwise the point of saturation would be quickly reached and the moisture deposited on the sides of the kiln and the hops themselves. Ventilation is closely connected with draft and is dependent upon it. Conditions which afford good natural draft usually provide sufficient ventilation.

Draft and ventilation, as well as drying itself, are very dependent on the temperature and humidity of the atmosphere. Draft or a definite upward movement of the air in a kiln occurs when heat is applied at its base. The cold air outside the kiln being heavier than the warm air within constantly tends to establish an equilibrium of pressure by flowing down to the base of the heated kiln. As a direct consequence the heated air is forced upward, and the cold air taking its place is in turn heated and will follow the same course. A continuous circulation is thus established, its velocity and volume depending on the difference in density of the outside air and the air within the kiln.

The changes of temperature in the external atmosphere have very marked influence on draft. In hop drying it is observed that the best draft is usually obtained about 2 or 3 o'clock in the morning. This is about the time when the greatest temperature differences exist between the outside and inside air, with a corresponding difference in pressure resulting in increased draft. This advantage, however, is largely offset by the great increase of humidity in the atmosphere at night. In the daytime when the air temperature is high great difficulty frequently arises in securing a draft without at the same time overheating the hops. Usually a difference of about 50° F. between the temperature under the kiln floor and that over the top of the kiln is necessary in California to cause a sufficient pressure to force the air through the hops. In Oregon a difference of 30° F. is generally sufficient to accomplish the same result, the reason for the difference being that the hops are not laid so deep on the floor and twenty to twenty-four hours are used in drying as against ten to twelve hours in some districts in California. Assuming that a difference in temperature between the atmosphere and the air in the kiln of 30° to 50° F. is necessary to cause a draft through the hops, it is

apparent that the greatest care must be used to avoid damage to the hops through overheating.

Many of the difficulties attendant on the use of natural draft have been overcome by recourse to forced draft. By this means a large volume of air is driven through the hops, instantly setting up a good circulation of air and rapidly carrying off the moisture, so that the hops do not undergo the long sweating and steaming process which is a necessary accompaniment of the use of natural draft. Drying is possible also at a much lower temperature, and this method presents many other advantages, among which is absolute control of a low, even temperature, giving an increase of soft resins, flavor, aroma, and weight.

NATURE OF THE CURING PROCESS.

When the hops are placed upon the floor of the kiln the cells which compose their tissues are still alive. Proper curing consists in bringing about the death of these cells through the gradual withdrawal of water from them at a moderate temperature. Within each cell are many chemical substances which remain separated so long as the cell is alive, but which are thrown out of solution by the loss of water from the cell and left in a form in which they are very readily soluble. If the removal of water does not proceed steadily, or if the vapors are allowed to settle back, moisture condenses on the hops and is readily reabsorbed and, coming in contact with the readily soluble substances, dissolves them. In this condition these substances cause blackening or discoloration and the hops are injured in other ways.

Death of the cells may be caused without much water loss by sudden exposure to high temperature. In such a case the chemical substances no longer remain separated, but flow together and form new compounds with resultant changes in color, aroma, and other desirable qualities. The cells may sustain a considerable water loss before they are killed, provided the temperature is kept below a certain point (about 110° F.). As soon as the death of the cell occurs and the flowing together of its compounds begins, drying should be forced somewhat more rapidly, in order to reduce the amount of water present as fast as possible, but even in this stage of drying the temperature can probably not long exceed 140° F. without injury to the quality.

PRACTICAL DRYING.

The most important and at the same time the most difficult part of hop production is proper drying. No other factor affects the quality, appearance, and market value as much as the manner in which the hops are handled during the curing process.

In the drying process three factors are of primary importance. These are (1) degree of temperature used; (2) length of time of

drying; (3) volume of air passing through the hops. Also, in drying at a very low temperature the humidity of the air is an important factor. Only the first two of the factors mentioned have been generally recognized, and the high temperatures used at present are the result of shortening the time of drying. It is possible to diminish the temperature materially without lengthening the time of drying by forcing through the hops a large volume of air at low temperature.

The first care is to properly lay the hops on the drying floor. They should be spread out evenly and loosely to a depth of 14 to 24 inches, depending upon the ripeness. In an uneven floor the heat will break through first in the thinner places, which quickly become dry, while the thicker portions remain damp. If the hops are trampled or otherwise packed together on the floor the heat will not readily pass through them and drying is rendered uneven. Some practical growers set a stout wire screen of about 5-inch mesh at the desired height above the floor and the hops emptied from the bags upon this fall lightly and evenly to the floor beneath. The top is then carefully leveled with a rake.

As soon as the floor is laid the fires are started and the heat is gradually brought up to the desired point. In from three to five hours the hops will have become heated throughout and sufficient moisture will be driven off so that the hot air will readily pass through them. Until this point is reached the temperature must be closely watched, as too rapid firing at first will cause the under layers to scorch. In sections where drying is accomplished in ten to twelve hours a very common practice is to turn the hops with a wooden barley fork when the lower layers are dry enough to rattle when stirred. This should be done only when absolutely necessary, as turning breaks and shatters the hops and a portion of the lupulin is lost. Since the hops can not be turned evenly this practice hinders uniform drying.

During the course of drying sufficient ventilation must be provided to carry off the moisture without at the same time cooling the sides of the kiln and the top of the hops enough to cause the moisture to be deposited. Warming the air and the sides of the kiln above the hops materially aids drying. In the more northerly hop regions the most successful kilns are ceiled to the top, thus better retaining the heat.

The almost universal failure to recognize the harmful effects of high temperature in drying has caused wide diversity in practice. Temperatures of over 200° F. are not uncommon. That this is far too high has been shown by experiments made in the field with hops cured on various kilns at different temperatures. Aside from ruining the flavor by overdrying or scorching, there is a distinct loss of valuable essential principles by drying at high temperatures. The vola-

tile oil, to which the aroma is largely due, is partly evaporated and the lupulin is rendered inferior, since the amount of the desirable soft resins becomes proportionately less as the drying temperature is increased. The best temperature for drying is yet to be determined, but every consideration indicates that it should be much lower than that commonly employed, probably between 100° and 140° F. Practical experience has shown that good drying may be accomplished with a temperature of 110° F., and the general trend of opinion is toward the use of the lower temperatures in drying. No fixed temperature, however, can be assigned as the most suitable for drying, because a degree of heat which at one stage of drying would probably be detrimental, at another would have no injurious effects. In taking the temperature care should be used to see that the thermometer is placed where the heat on the hops is greatest. This point has been found to be just below the drying floor. During the first part of the drying a thermometer below the cloth of the drying floor will register higher than one placed on the floor at the bottom of the hops, and one placed just above the hops will register 30° to 40° lower until drying is perhaps half finished or until the heat breaks through the hops. During this period of drying the heat is concentrated on the lower layers of hops, and here the greatest care is necessary to avoid injury. When the heat begins to break through the hops the upper thermometer will show a rapid rise of temperature, while the one below the floor will show a decline. From this point on to the end of the drying the two thermometers will show approximately the same degree of temperature.

As already stated, hops are frequently cured in from ten to twelve hours, but, other conditions being equal, a higher temperature must be used than when the time is extended to eighteen or twenty hours. The advantages of slower curing or curing at a lower temperature should be universally understood by hop growers. Even a moderately high temperature continued too long will damage the quality of the hops, the same as too high a temperature. In order that the hops may be dried at as low a temperature as can be made to do the work a strong draft is necessary during the drying to continuously carry off the moisture from the hops. There is no doubt that the principle of the air-blast kiln at present most satisfactorily meets these requirements.

No definite rule has yet been given for determining when hops are sufficiently dried. The condition in which they may be safely removed from the kilns can at present be told only by experience. The amount of drying will vary from day to day, being dependent upon weather conditions and the ripeness of the hops. In general, drying should continue until nearly all the stems or cores are shriveled, but are still soft and pliable. If overdried, the stems crumble

and break readily, and the lupulin loses its bright, clear yellow appearance and turns brown. If hops are taken off the kilns slack or underdried they are very apt to heat, which turns the lupulin brown, and to develop a sour musty smell which makes them undesirable. If they are high dried or overdried they will break badly and become chaffy, and they also develop a burnt, peanutty odor.

The thin leaf-like portions of the hop usually become dry enough to break readily by the time the stems are dried sufficiently to make safe the removal of the hops from the kiln. This condition may be remedied by closing the ventilators half an hour before the drying is finished. This will also somewhat restore hops that have been overdried, as the further escape of moisture from the kilns is prevented, which then tends to equalize in the hops, soon softening and toughening them. Many careful dryers make a regular practice of gradually closing the ventilators as drying proceeds, and finish the kiln with them tightly closed. The same result may be indifferently accomplished by opening all the doors of the kiln and letting the hops cool for about an hour, as by this process they absorb moisture from the air and become less brittle.

SULPHURING.

The practice of sulphuring hops, which is now almost universal, is a response to the demands of the market chiefly for the pale yellowish-green grades. The use of sulphur not only gives the hops the desirable yellow color, but makes them more uniform in appearance, thus increasing their salability. Many dealers are guided more by color than by other qualities, and such dealers have been known to rate unsulphured hops as inferior, while sulphured hops from the same field were classed as choice.

The use of sulphur improves the color by bleaching, injures the micro-organisms present, and retards the deterioration of certain of the desirable chemical constituents, thus improving the keeping quality, and, according to a widespread belief, accelerates the drying. The sulphur is usually burned beneath the kiln floor at the commencement of drying. The usual practice is to use from 1 to 4 pounds of sulphur for each 100 pounds of undried hops. The action of the sulphur is most energetic while the hops are yet fresh and damp. Only refined sulphur of guaranteed purity should be used, as the crude sort usually contains impurities which may injure the quality of the hops. Certain of these impurities will become concentrated in the lower layers of hops on the kiln floor, and after these hops are baled some bales may show an unusually high percentage of

these impurities. The best results are obtained with what is known commercially as rock sulphur. Roll sulphur differs from this only in the form in which it is cast and has no greater bleaching power.

TYPES OF KILNS.

With respect to construction, there are many kinds of kilns. Whatever kind of structure is used for drying hops certain features are essential, and these may be comprehended in the description of a typical kiln. As regards methods of operation in the United States two general types must be recognized. In the stove kiln the hops are heated by a stove or furnace placed under the floor; in the air-blast kiln a current of heated air from the outside is forced in by a fan.

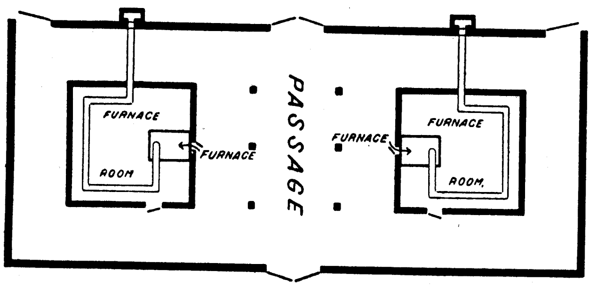

Fig. 6.—Ground-floor plan of stove kiln.

The Stove Kiln.

The type of hop drier which consists essentially of a furnace room heated by a large stove or furnace and a drying room immediately overhead, into which the heated air from the furnace passes through cracks in the floor, is known as the stove kiln. The stove may be situated in the center of the furnace room, but is commonly placed at one side and so arranged that the firing can be done from the outside. A very successful type of kiln is shown in figures 6, 7, 8, and 9. This combines the features of the simple furnace room with those of a style of kiln used on the Pacific coast and known as the "double-hopper" kiln. The building is a well-sided frame 36 feet square and measures 32 feet to the plate, from which the four-sided roof is carried up at one-half or two-

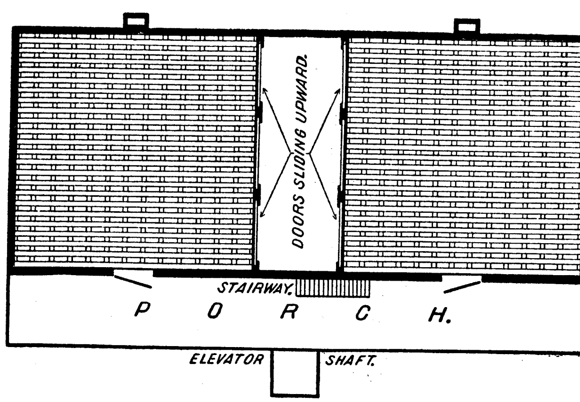

Fig. 7.—Plan of second or drying floor of stove kiln.

thirds pitch. At the top an opening 8 feet square is left, over which is built the ventilator or cupola to a height of 12 feet. Two, or sometimes four, shutters, hinged to the sides of the cupola at the top, are fitted with ropes and pulleys, by means of which they may be opened and closed. Six feet below the plate, or 26 feet from the ground, are placed the joists which support the drying floor, which is composed of slats 1 to 2 inches wide carefully spaced at the thickness of one slat apart (fig. 7). Over the slats is stretched a kiln cloth or carpet of 8 to 10 ounce jute, similar in quality to the ordinary barley sack. From the drying floor to the plate the inner wall of the kiln is ceiled in order to retain the heat. In humid regions the best results are obtained when the ceiling is carried up on the rafters nearly to the top of the roof. In the center of the room below the drying floor is a second inclosure 18 feet square, made of 2 by 4 inch studding, 10 feet high, and lathed and plastered on the outside to within 10 inches of the floor, leaving next the ground an open space for the admission of air.

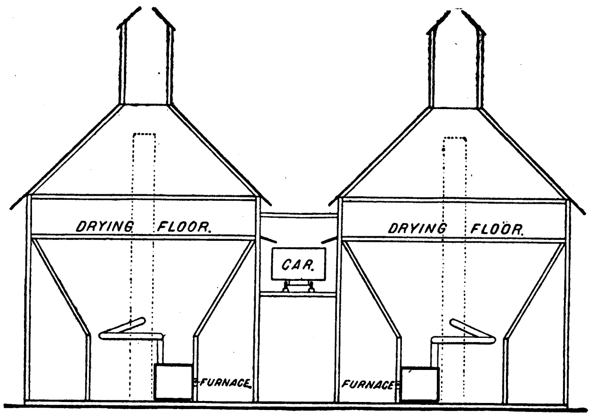

FIG. 8.—Sectional elevation of stove kiln.

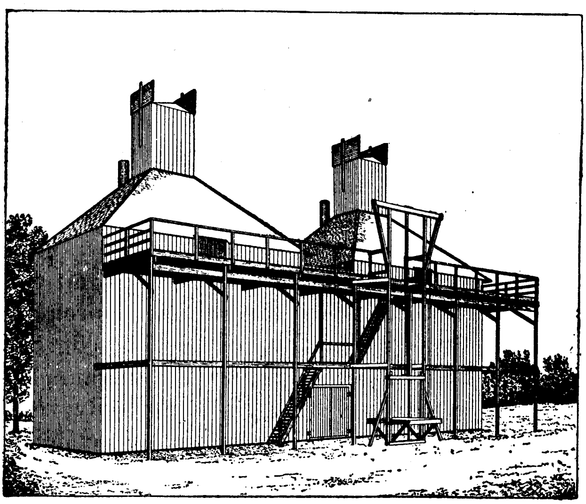
FIG. 9.—Perspective of stove kiln the plans of which are shown in figures 6, 7, and 8.

The draft is largely controlled by means of large doors opening to the outside from the main room. In the type of kiln without the hopper air is admitted through openings in the outside walls close to the ground. These draft openings are provided with shutters which in

strong winds are closed on the windward side to prevent uneven drying.

From the top of the studding used in making the wall of the inner inclosure, timbers run on a slant to the outside walls, which they join just below the drying floor. These timbers are likewise lathed and plastered, forming as it were a huge hopper below the drying floor (fig. 8). The furnace is set in one side of this inner room, and the large pipe therefrom makes a circuit of the hopper at about 10 feet from the ground and is then led to the chimney outside. This kiln may be single or double, as shown in figures 6, 7, and 8. The size may be reduced to suit the needs of the user, and brick or stone may sometimes be used with advantage in its construction. The drying floor, however, should never be less than 20 feet above the ground, on account of the danger of scorching the hops.

The superior advantages claimed for this kiln are the even distribution of the heated air to the drying floor, the strong draft induced by causing all the air to pass in through the small furnace room where it is highly heated, and the distance of the drying floor from the furnace, whereby the danger of scorching the hops by direct radiation is largely diminished. In this kiln, also, the objections to the real hopper form are largely overcome, since the lower portion of the woodwork does not come so close to the stove as to be in danger of catching fire.

On a level with the drying floor at one side of the kiln a platform is constructed, from which the green hops are transferred to the drying floor. When possible the kiln is erected on sloping ground, so that the hops may be unloaded thereon from wagons, which approach the kiln on a driveway formed by a slight embankment. Inclined wooden driveways, as shown in figure 14, are sometimes used, but the more common practice is to bring the hops from wagons on the ground to the platform by means of an elevator (fig. 9).

At one side of the drying floor, doors sliding vertically permit the hops to be readily shoved off into the hop car, which is brought alongside the kiln with its top just below the level of the floor (fig. 8).

The "double-hopper" kiln has failed to realize the advantages hoped for on its introduction some years ago. It is not only very liable to destruction by fire, but the lower hopper limits too much the air space below the hops and does not give the necessary draft at the temperatures most suitable for curing.

The Air-Blast Kiln.

The desirability of maintaining a strong draft through the hops while drying on the kiln has led to the employment of various artificial means for this purpose. A device for producing a forced draft

which has long been used in England, and frequently tried in the United States, but with poor success, is an exhaust fan placed in the ventilating shaft of the kiln. In an improved method of drying with a forced draft which has been used successfully on the Pacific coast during the last few years a blast fan is used to drive the air through the hops from below. The main features of this method are illustrated in the air-blast kilns of the Pacific coast shown in figures 10, 11, 12, and 13.

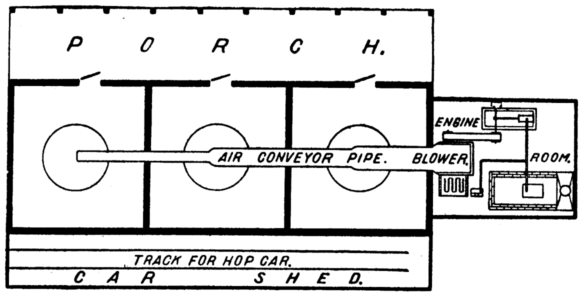

FIG. 10.—First-floor plan of air-blast kiln.

These kilns, constructed of wood, of corrugated iron, or of concrete blocks, are from 30 to 36 feet square, and for economy and convenience three or more are usually operated in series under a single roof (fig. 13). Two drying floors are provided in each kiln (fig. 12), the first 9 feet from the ground and the second 7 feet above the first. The lower floors are generally made of slats and covered with a kiln cloth in the usual manner (fig. 11), but the upper floor is made of removable wire-covered sections. This distance from the ground to the plate is 18 feet and to the comb of the roof 30 feet. A low ventilator, fitted with shutters at the sides, terminates the roof and runs the entire length of the building. The draft in these kilns is produced by a blast fan from 7 to 9 feet in diameter, driven by a steam engine at a rate of speed high enough to produce a slight pressure in the air-tight room below the hops. As soon as the fan is started the pressure is established and the air quickly passes through the hops and escapes at the ventilators in the roof.

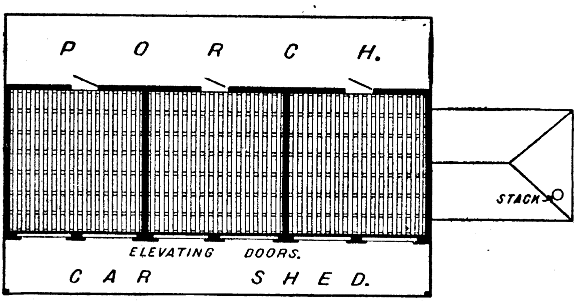

FIG. 11.—Plan of second or drying floor of air-blast kiln.

The air intake is outside the kiln, and just before the air enters the fan it is drawn through a sectional steam heater, constructed of 1-inch iron pipes, whereby its temperature may be maintained constant at any desired point. A large pipe, about 5 feet in diameter, conveys the air into the kilns (figs. 10 and 12). At the center of each

kiln the air is delivered downward through a curved outlet of the main pipe, 34 inches in diameter, and fitted with a damper by means of which the amount of air admitted to the indivdual kiln is controlled. Below each outlet pipe is a saucer-shaped concrete-lined depression in the kiln floor which. receiving the inrushing air, deflects and distributes it evenly to the drying hops above.

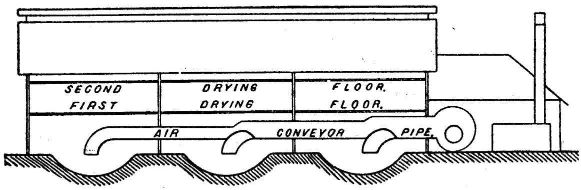

FIG. 12.—Sectional elevation of air-blast kiln.

In a kiln 36 by 36 feet, when the hops are laid 15 inches deep, the green weight is estimated at 7,500 pounds. The conversion of the hops—that is, the number of pounds when green required to produce 1 pound when dry—varies from $3\frac{1}{2}$ to 4. This means, therefore, that in drying a floor of hops of the dimensions just given, from 5,000 to 5,500 pounds of moisture must be carried off. To accomplish this speedily a very large volume of air is necessary if the temperature is kept below the point where the quality of the hops is affected. The superiority of this type of kiln when equipped with a blast fan of sufficient size lies in the possibility of driving through the hops a large volume of air at a low temperature, thus carrying away the moisture and perfectly drying the hops, while overheating, overdrying, and scorching are avoided.

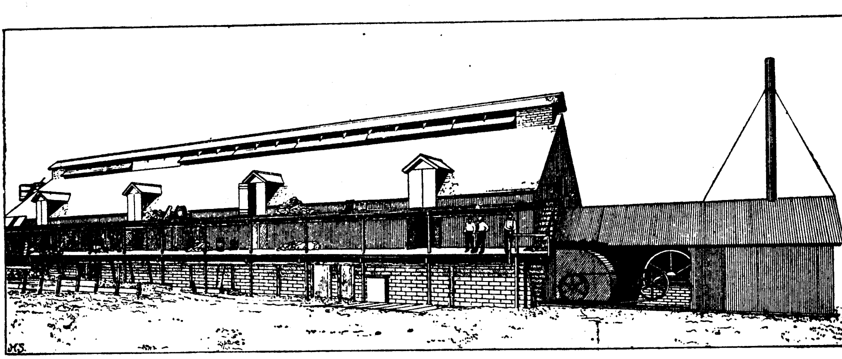
FIG. 13.—Perspective of air-blast kiln the plans of which are shown in figures 10, 11, and 12.

The ordinary stove kiln may be readily converted into an air-blast kiln by the installation of blowers and devices for heating the air. Figure 14 shows a group of six stove kilns so modified at an expense much less than that necessary for the construction of an entirely new plant.

TREATMENT IN THE COOLER.

A very important part of the successful curing of hops is the handling which they receive in the cooling or storage room. The

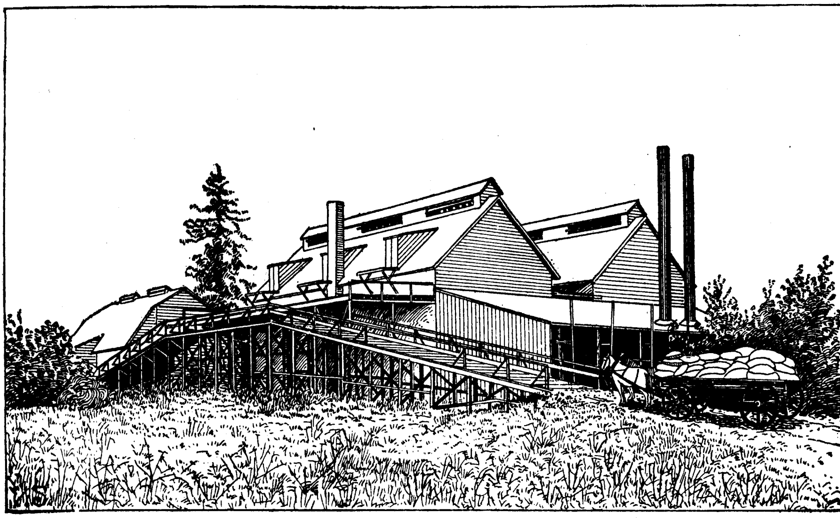

FIG. 14.—Group of six stove kilns converted into an air-blast plant.

building used for this purpose (fig. 15) is now generally detached from the dry kiln and placed at a distance of 100 to 200 feet as

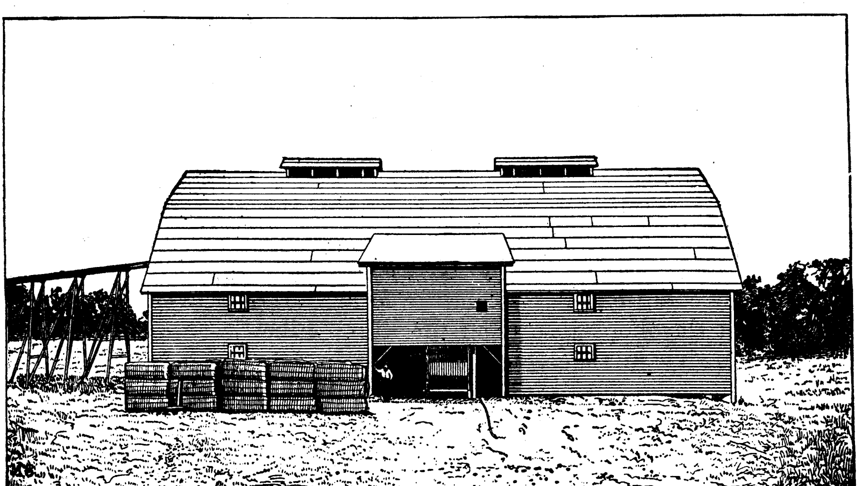

FIG. 15.—Elevation of cooling house, showing position of baling press.

a safeguard against fire. Figure 16 shows a sectional elevation of a cooling house with the two storage floors above the baling floor.

If necessary the lower floor may also be used for storage, but this necessitates elevating the hops to the second floor for baling. The building should be of tight construction, especially in humid regions, to prevent the loose hops from absorbing too much moisture from the air.

The kiln is connected with the cooler by an elevated tramway, over which is run a large car carrying the freshly dried hops. The sides of the car are hinged so as to swing open from the sloping bottom, allowing the hops to be readily removed with little handling.

The hops are spread out on the floor of the cooler, where they lose their heat and absorb some moisture from the air. The stems are usually not so dry as the other parts of the hop, and during the sweating process the moisture is equalized and the hops become tough and pliable. The best informed growers recognize that other important changes occur during the sweating process which materially affect the quality of the product. A finer and more pleasing aroma, as well as a better physical appearance, is developed during sweating, provided the process is carefully watched and the hops are prevented from becoming too moist or heated. Under ordinary circumstances these two evils are avoided by loosening up the hops and turning them over with forks or by moving them to another part of the cooler. If taken in time, slack hops may be brought out in this way and practically freed from their sour, musty smell. If the hops in the cooler become too moist, their condition may be improved by dumping over them a car full of hot dry hops just from the kiln. Likewise hops that have become too dry in the cooler may be helped by mixing with them hops taken from the kiln a little before they are properly dry. Great care and good judgment are necessary for proper handling in the cooler, and more attention given to this phase of hop curing will certainly result in an improved quality of product.

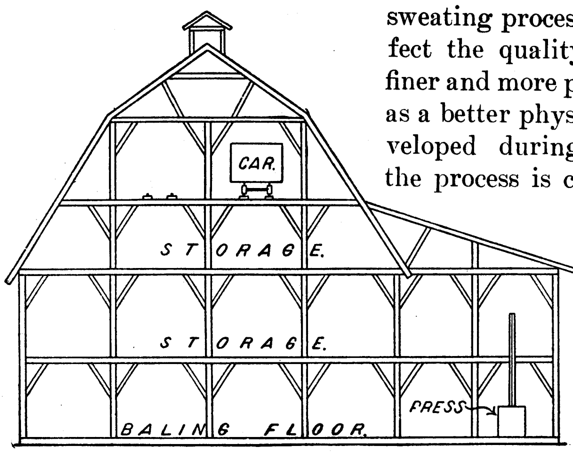

FIG. 16.—Sectional elevation of cooling house.

BALING.

After the hops have been in the cooler for a week or ten days they will have passed through a sweating process and be in good condition to bale. Hops may be left in bulk for many weeks and

suffer little injury if the storehouse is tightly closed to exclude atmospheric moisture. When suitable for baling, hops contain just enough moisture to make them pliable and to prevent their breaking when compressed. If too much moisture is present in the bale, the hops will soon heat and turn black, being damaged thereby both in color and aroma, or they may be ruined entirely.

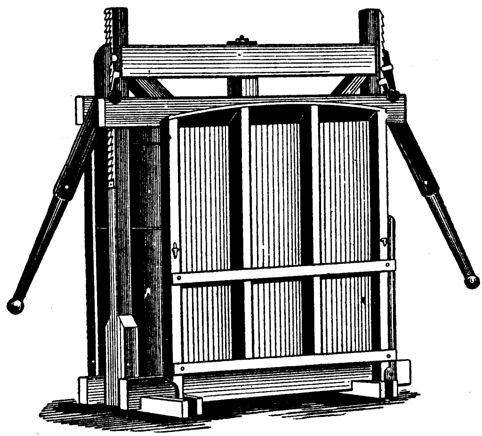

FIG. 17.—A baling press operated by hand.

For pressing the hops into bales several styles of hop baler are used. In some sections where only a small crop is produced a hand-lever press is used. The form of this style of press, as shown in figure 17, produces a bale measuring 24 by 18 by 63 inches.

For handling large crops some form of power press is always employed. A modern press which is easily operated with one horse is shown in figure 18. This is a vertical machine 10 feet 4 inches high and 30 inches wide. The doors swing upward to open, and when closed are locked by a bar lock that fits a lug at each end of the press. The end gates are loose and may be easily removed when the doors are open. The follower is made of 4 by 4 inch timber and 1¼-inch boards, with a 1 by 6 inch steel bar across the top, to the ends of which twin cables are attached, by means of which the follower is brought down. The cables wind on a winch made with a 26-inch sheave and a 6-inch drum, using a sweep 12 feet long. Since the cable is wound first on the 26-inch sheave and then feeds onto the 6-inch drum, the downward motion of the follower is rapid at first, but becomes very slow as the volume of hops reaches the proper size for the bale. In this press the box is refilled and the follower brought down the second time for each bale. The bale produced usually measures 19 by 26 by 53 inches.

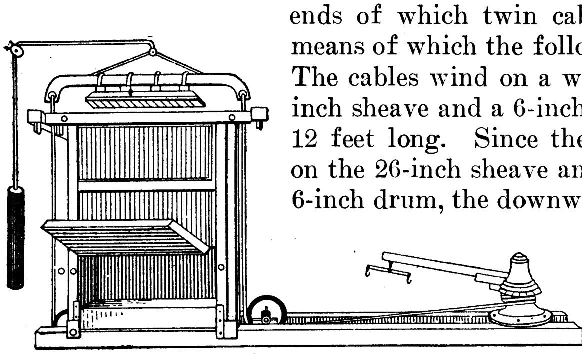

FIG. 18.—A power press operated by one horse.

The so-called Sacramento or "bull wheel" press (fig. 19) requires two horses for its operation. The box of the press measures 20 by

52 inches and is 8 to 10 feet high. Below the box is a 3-inch steel shaft, on one end of which is fastened a power wheel 10 to 12 feet in diameter. On the shaft are two 8-inch pinions which mesh into cog racks 4 inches wide bolted to two 4 by 4 inch 16-foot scantlings which work up and down. These scantlings are connected at the top by a 4 by 12 inch crosspiece 7 feet long. From the crosspiece drop two 4 by 4 inch pieces from 8 to 10 feet long, to the free ends of which is attached the follower, which fits into the box and, when the power is applied by means of the rack and pinion, presses down the hops.

The lower section of each side of the box consists of a door hinged to open upward. In baling, the bottom of the press is covered with a piece of baling cloth $2\frac{1}{2}$ yards long and from 42 to 46 inches wide, the doors are closed, the box is filled with hops, another similar cloth is spread over the hops, and the follower is brought down. The doors are then opened, the edges of the cloth sewed together with hemp baling twine, and the bale is removed from the press. The average bale from this press measures 20 by 24 by 52 inches and weighs 180 to 200 pounds.

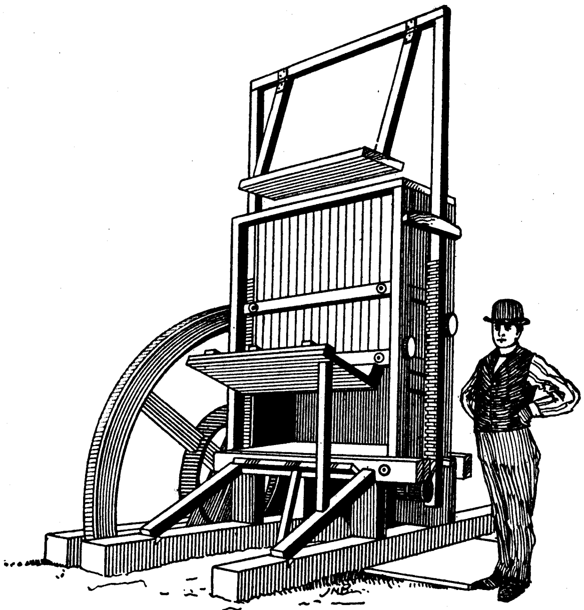

FIG. 19.—A power press operated by two horses.

The practice of trampling the hops to facilitate filling the box should be entirely discontinued, since the broken hops resulting therefrom detract from the selling qualities. While filling the box the corners of the bale may be slightly tamped, but even this should be carefully done, especially if the hops are dry. More careful handling is urged, as the hops are often broken and crushed on the floor before being baled and this gives them a bad appearance.

Hops are baled in jute bagging, 16 threads or less to the inch. About 5 running yards of bagging are required for each bale. This weighs from $7\frac{1}{2}$ to 10 pounds, and for it 5 pounds tare is allowed in selling.

ACREAGE AND YIELD.

In 1917 the area of hops harvested was 29,900 acres, which represented a decline of 14,000 acres from the preceding year. In Table 1, compiled from statistics furnished by the Bureau of Agricultural Economics, United States Department of Agriculture, is shown the acreage of hops in the principal hop-growing States for the years 1918 to 1926, inclusive.

TABLE 1.—*Acreage of hops in the United States from 1918 to 1926, inclusive.*

State.	1918	1919	1920	1921	1922	1923	1924	1925	1926
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
New York	3,800	1,000	1,000	1,000	(1)	(1)	(1)	(1)	(1)
Washington	3,100	2,000	3,000	3,000	2,400	1,800	2,350	2,300	2,400
Oregon	10,000	9,000	12,000	12,000	12,000	9,000	12,000	13,000	13,000
California	11,000	9,000	12,000	12,000	9,000	5,000	6,000	5,000	5,400
Total	27,900	21,000	28,000	28,000	23,400	15,800	20,350	20,300	20,800

1 Not reported.

The yield of hops varies widely according to locality, and within the locality according to season, soil conditions, and methods of cultivation. In Table 2 is shown the average production of hops per acre for the years 1918 to 1926, inclusive.

TABLE 2.—*Yield of hops per acre, by States, from 1918 to 1926, inclusive.*

State.	Average yield per acre.								
	1918	1919	1920	1921	1922	1923	1924	1925	1926
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
New York	330	690	950	580	(1)	(1)	(1)	(1)	(1)
Washington	948	1,340	1,910	1,700	1,410	2,151	1,817	2,116	2,320
Oregon	350	850	725	770	800	722	1,150	1,200	1,150
California	1,136	1,550	1,575	1,185	1,640	1,480	1,600	1,600	1,650
Average of the above	732.8	1,189.0	1,224.3	1,040.7	1,185.6	1,124.6	1,359.7	1,377.9	1,414.8

1 Not reported.

In seasons of good production, on the better soils, the yield will usually be much larger than the averages given. In California an acre may produce 1,400 to 2,200 pounds; in Washington, 1,200 to 2,000 pounds; in Oregon, 1,000 to 1,600 pounds; and in New York, 800 to 1,500 pounds.

Table 3, compiled from statistics of the Bureau of Agricultural Economics, gives the approximate annual hop production in the United States for the years, 1918 to 1926, inclusive.

TABLE 3.—*Annual production of hops in the United States, by States, from 1918 to 1926, inclusive.*

(In thousands—i. e. 000 omitted.)

State.	1918	1919	1920	1921	1922	1923	1924	1925	1926
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
New York	1, 254	690	950	580	[1]	[1]	[1]	[1]	[1]
Washington	2, 939	2, 680	5, 730	5, 100	3, 348	3, 872	4, 270	4, 973	5, 568
Oregon	3, 500	7, 650	8, 700	9, 240	9, 600	6, 498	13, 800	15, 000	14, 950
California	12, 500	13, 950	18, 900	14, 220	14, 760	7, 400	9, 600	8, 000	8, 910
Total	20, 193	24, 970	34, 280	29, 140	27, 744	17, 770	27, 670	27, 973	29, 428

[1] Not reported.

MARKETING.

The most serious problem confronting the hop grower is how to market his product at a figure which will give a fair return for investment and labor. Owing in part to great fluctuations in prices, hop growing from a business point of view is extremely variable and uncertain. The state of the market is determined largely by the stock of hops held in storage from the previous year, by the crop conditions at home and abroad during the current year, and by the probable demand as judged from a comparison of the two conditions just mentioned. While the state of the market is conditioned by these three factors, it is influenced heavily by the dealers, hop merchants, or middlemen who stand between grower and consumer.

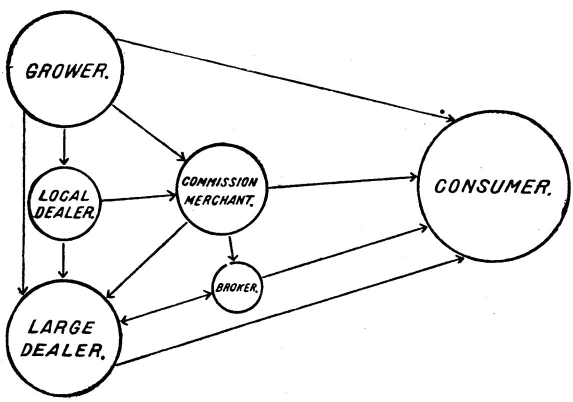

FIG. 20.—Diagram showing the movement of hops into market.

Hops may move into the market in a number of ways and reach the consumer through various channels. The relations of grower and consumer in some of the more direct lines of transfer are illustrated in the accompanying diagram (fig. 20).

Only a small percentage of hop growers sell direct to consumers, so the bulk of the trade passes through the hands of middlemen. Sales may be made to the large dealer direct through his buyers or to the local dealer, who in turn sells to the large dealer; or growers may sell through a commission merchant who may act as agent for both grower and consumer. The broker, or factor, serves as a go-between for dealers or for dealer and consumer. All these middlemen occupy a recognized legitimate place in the trade so long as

they confine their operations to buying and selling at market prices as fixed by supply and demand and depend for their profits upon the favorable terms which they may be able to make in the regular course of trading. Under existing conditions the hop crop could not be marketed without the middlemen. Growers with small holdings remote from consumers could scarcely find a market for their product, even if the difficulties involved in arranging credit were overcome. The grower is usually in need of money and demands immediate payment; on the other hand, the consumer may not have funds available to pay cash for his hops at the time when it is necessary to make the purchase. The dealer solves the difficulty by relieving the grower of his stock and making cash payment therefor or a suitable short-time arrangement and by selling to the consumer on terms to suit his convenience.

Although much significance is commonly attached to the locality in which the hops are produced, it is apparent that too much emphasis is laid on geographical origin as a standard of quality. It has been repeatedly demonstrated that dealers and consumers can not tell with certainty the section of the country a sample comes from by examination alone. Even samples from the same yard, when the conditions of drying have differed somewhat, have been ascribed to widely different sections by expert judges of hops.

The price which a consumer will pay for hops depends largely on their origin, thus making it frequently possible to deliver hops grown in one section when the sale was made on hops from another which commanded a different price. Unfortunately, there is no definite standard of quality in judging hops, and there is apparently too much importance attached to origin alone. While geographic origin may be of some importance, its usefulness as a standard of quality is small compared with the tests usually applied in judging the value of hops. In determining the relative quality of different lots of hops a fixed standard of valuation founded on intrinsic qualities rather than preference would be exceedingly valuable to both producer and consumer.

The present unsatisfactory conditions of marketing offer opportunities for improvement along several lines. One of the greatest needs of the hop industry is more complete and accessible statistics of production and consumption, not only that growers may govern their acreage by the prospective demand, but that, by knowing the amount consumed during the current year, the stocks remaining in the hands of the consumers, and the crop conditions at home and abroad, an intelligent opinion may be formed as to the probable relation between supply and demand and what prices may therefore be reasonably expected.

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